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PATENT

UNITED STATES PATENT APPLICATION

FOR

EXTENSIBLE GPS RECEIVER SYSTEM

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EXTENSIBLE GPS RECEIVER SYSTEM

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a mechanism for processing positioning signals such as those received from the Global Positioning System (GPS).

ART BACKGROUND

The global positioning system (GPS) has become extremely popular for a number of applications. GPS receivers are now incorporated into a variety of systems including consumer electronic systems in which the location information or time information provided by GPS supplements the other information provided by the system. Thus, more and more industries are realizing the advantages that GPS can provide.

Typically, when a customer, such as an original equipment manufacturer (OEM) develops a particular application of GPS, the GPS manufacturer generates the application code in accordance with the customer's specification. The GPS manufacturer designs and codes the user application of GPS, as the processing performed by the GPS receiver has strict timing and processing requirements that cannot be disturbed by other processing such as the user application processing. Unless carefully written, the execution of customer code can conflict with the GPS processing code. In addition, there is the danger of the user code overriding sections of memory

containing the GPS processing code or GPS data used in processing. Thus, the GPS manufacturer cognizant of these restrictions carefully develops the user application code for a particular customer. This is a time consuming and costly process. It is therefore desirable to develop a system that insulates the GPS processing portion and data from the user application portion such that the user application portion has access to the positioning data generated by the GPS processing portion without the concern that the user application portion will corrupt the GPS processing portion and data of the receiver.

SUMMARY OF THE INVENTION

The apparatus and method of the present invention provides a processing system in which the processor is coupled to a Global Positioning System (GPS) receiver circuitry that receives positioning signals and, in accordance with well known GPS processing techniques, generates the positioning data for access by a user application process executing on the same processor. A firewall is established between the user application process and the GPS process. The firewall prevents the user application process from conflicting with time critical processing by the GPS process and further prevents the user application process from overriding the memory areas allocated to the GPS process.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the present invention will be apparent to one skilled in the art from the following detailed description in which:

Figure 1 is a simplified block diagram of one embodiment of the system of the present invention.

Figure 2 is a block diagram illustrating the structure of the processes in accordance with the teachings of the present invention.

Figures 3a and 3b illustrate one class of GPS objects in accordance with the teachings of the present invention.

Figures 4a, 4b, 4c, 4d, 4e, 4f and 4g illustrate another class of GPS objects in accordance with the teachings of the present invention.

Figures 5a and **5b** illustrate a class of GPS objects in accordance with the teachings of the present invention.

DETAILED DESCRIPTION

In the following description, for purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice the present invention. In other instances well known electrical structures and circuits are shown in block diagram form in order not to obscure the present invention unnecessarily.

The system of the present invention provides a user configurable Global Position System (GPS) receiver system in which the user application processing does not interfere with time critical positioning processing. A simplified block diagram is shown in **Figure 1**. The system and methods of the present invention are described below with reference to a GPS receiver. However, it is contemplated that the present invention can be implemented in a variety of positioning system receivers including GLONASS, Loran-C and Pseudo-lite receivers.

Referring to **Figure 1**, a GPS antenna and corresponding receiver circuitry **10** is connected to processor **15** via bus **20**. The processor **15** interacts with the GPS hardware such as the correlators, voltage control oscillator (VCO's) and the like, located in receiver **10** to acquire and track GPS signals transmitted by satellites. Thus, GPS receiver **10** receives GPS signals from satellites under the control of processor **15** acquires and tracks the satellites in order to receive the positioning signals. The processor **15** further processes the positioning signals to generate positioning data. Typically, the positioning data includes a time, angular and distance measurements. The specific data generated can vary according to implementation and is well

known in the art. Furthermore, the control functions performed by the processor to acquire and track signals are well known in the art and will not be discussed further herein.

As is well known in the art, positioning signal processing is time critical in nature. Therefore, delays in processing the positioning signals can cause significant error in the computations. Processor **15** not only performs position signal processing, but also performs user application processing. The code and data for the user application as well as the positioning signal code and data are preferably stored in memory **25**, which is coupled to processor **15** via bus **20**. It is contemplated that memory **25** may also be coupled to processor **15** through a separate bus (not shown). In addition, the system includes a variety of I/O devices, such as GPS antenna/receiver **10**, a display **30** and at least one user input device input device **35**, such as a keyboard or mouse. The use of these I/O devices is programmable according to the user application.

Figure 2 is a block diagram illustrating the process structure that enables the positioning signal processing to be performed without encumbrance by the user application processing. The processor is controlled by an operating system which receives the instructions of the executing processes and controls the processor accordingly.

Although not limited as such, in the present embodiment it is preferred that a real-time operating system **205** is used to address the time critical nature of the satellite signal processing. The operating system **205** is connected to the code **210** used to control the input/output devices including the GPS receiver. One example of a real-time operating system is the Vx Works® embedded operating system marketed by WindRiver Systems. The processor processes the satellite signals in accordance with the

GPS process **215**. Thus, GPS process **215** interacts in the real-time manner with the real-time operating system **205** to receive positioning signals through I/O control 210 and controls the GPS receiver circuitry through I/O control **210** to accurately acquire and track the satellite signals.

As noted above it is desirable to enable the user to configure the system for the user's particular application. Therefore, in order to provide this capability, a firewall ~~220~~ **250** is established between the GPS process **215**, real-time operating system **205**, and the user application **225**.

In the present embodiment a virtual machine is used **230** to provide a level of protection from a user application program interfering with the data utilized in the GPS process **215**. For example, the virtual machine **230** prohibits the user application process **225** from specifically accessing or corrupting a particular memory location not previously allocated to that application as the virtual machine acquires the application to address a particular memory location using a virtual address. In addition, the application process must have the privilege of accessing that particular address. Thus, virtual machine **230** provides one level of the firewall **250**.

A virtual machine is a software computer that executes programs that have been compiled into byte code. As noted above, the virtual machine separates the hardware and system software from the application software. Thus, system independent applications can be developed in any language that has a compiler that generates the virtual machine byte code. Applications once complied with byte code can be downloaded and executed as any processor that executes a virtual machine. One such virtual machine, is the Java Virtual Machine, by Sunsoft, Mountain View, California.

The firewall **250** further is required to prohibit the user application **225** from interfering with the time critical processing of the GPS process **215**.

In order to protect against this potential problem, the user application processes, as executed by virtual machine **230**, are set to a priority that is lower than the priority of the GPS process **215**. For example, this is done by setting the priority of the GPS process to the highest priority in the operating system **205**. Thus, any other process, such as the user application process will run at a lower priority, thus insuring that the GPS process **215** executes in a timely manner.

Continuing reference with **Figure 2**, in the present embodiment, an application programming interface (API) **240** is provided to simplify the user task of developing the user application. The API **240** preferably includes a number of functions that are accessible by the user application. In the present embodiment, the system is programmed using object oriented technology, such as C++; alternately the Java language can be used. **Figures 3a** and **3b** illustrate the Java objects for getting information to perform routing processes. **Figures 4a - 4g** illustrate objects used to acquire time information from GPS signals. **Figure 5a** is illustrative of GPSfix objects that can be used to get location information, i.e., a "fix". In the present embodiment, it is preferred that the GPSfix classes are constructed as class hardwarefix or simfix, wherein class hardwarefix , when initialized, includes communication between the class and the hardware. Furthermore, the object created receives data from the GPS hardware receiver. Simfix is a class of superclass GPSfix that users can instantiate to obtain a simulated GPS fix. When the class is initialized (e.g., the first time it is used), a simulator is started that propagates meaningful positions over time. Furthermore, the class includes methods to deal with simulation, e.g., defining regions and dynamics of simulated data. Simfix is used to provide an applications developer with a realistic model of GPS data.

It is readily apparent that a system developer can provide a variety of objects to address potential user applications. Thus, the user in this embodiment is further isolated from the operating system **205** through the API **240**. The resulting system provides a system readily adaptable by a variety of users for a variety of applications without the concern of interference of the time critical GPS processing.

The invention has been described in conjunction with the preferred embodiment. It is evident that numerous, alternatives, modifications, variations, and uses will be apparent to those skilled in the art in light of the foregoing description.